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INFLUENCE OF CAMBIAL CONTACT LENGTH ON GRAFT SURVIVAL AND LEADER ELONGATION IN DOUGLAS-FIR

by Donald Copes, *Associate Plant Geneticist*

First-year graft survival under field conditions is subject to many variables. Influence on grafting success of low relative humidity and temperature (Holst 1956, Nienstaedt et al. 1958, Shippy 1930, Sitton 1931, Webb 1961), climatic conditions and graft type (Orr-Ewing and Prideaux 1959, Mowat and Silen 1957), poor cambial matching (Hartmann and Kester 1959), and scion pretreatment (Zak 1955) has been reported. One factor influencing early survival, largely overlooked by past investigators, is the length of matched cambial edges between the scion and stock. This study, although originally aimed at investigating the long-term influence of graft types on the appearance of incompatibility symptoms between scion and stock, was found to yield fairly conclusive evidence that length of cambial contact was an important factor in 1st-year survival.

METHODS

A complete description of study methods that would emphasize graft types would serve little purpose to the reader. In this publication, methods pertaining to length of cambial contact are highlighted. Great variation in lengths of cambial contact was automatically obtained by making graft types differing in number of sides on which potential union areas could develop. Length of vertical cuts also varied considerably between graft types.

Graft types studied were splice, long cleft, short cleft, stub cleft, side, saddle, and top notch. Five of the seven graft types had 12 grafts of each in which the cambial edges of the stock and scion fitted together on both sides of the graft. Twelve grafts of each

type were also made where the cambial edges of the scion and stock were fitted together on only one side of the stem. This latter condition resulted from grafting small-diameter scions on large-diameter stocks. Well-matched scion and stock grafts were made by grafting scions and stock of exactly the same stem diameter (fig. 1). Two graft types, which are exceptions in study design just stated, were the side graft and the stub-cleft graft. In the side grafts, only the condition where both sides of the graft matched exactly was used. In the stub-cleft group, only one side of the graft could be made with matched cambiums because of the extreme difference in scion and stock diameters. All grafts used were standard types and are illustrated in most plant propagation books such as Kains and McQuesten (1942). No detailed descriptions of graft types will be presented because comparisons between types were not possible. The major factor found to influence graft behavior was length of cambial contact between stock and scion.

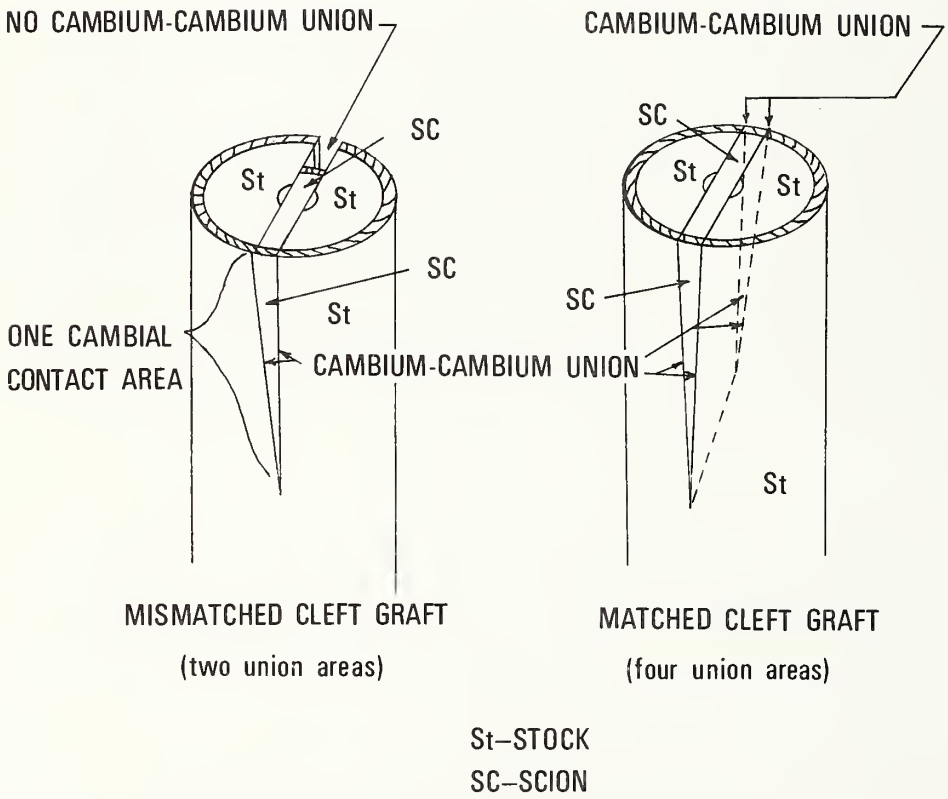


Figure 1.--Cleft graft unions, as seen in the matched and mismatched stock-scion cambium positions.

Douglas-fir grafts were made by cutting off branch tips and grafting them upon the same branch from which they were cut. With this technique, no stock-scion interaction effects produced by unlike genotypes could occur. No scion storage problem was involved with immediate regrafting. All stock trees were decapitated about 15 cm. above the 1964 whorl, and two stub-cleft grafts were placed upon each stub. All other graft types were made on the tips of the 1964 branches. Twelve branches of each stock tree were grafted. Only 1-year-old scion wood of each tree was grafted. Scions were grafted upon 1-year-old stock wood, except for the stub-cleft grafts which were placed on wood of older origin. Stub-cleft and side grafts were the only types made with scions collected from stock branches other than those to which they were originally attached. This resulted because of the nature of the graft types.

The length of the cut surface within each graft type was made as uniform as possible, but between graft types the length of cut surface varied greatly (table 1). This latter fact ruled out a valid comparison between graft types. Measurement of the actual cambial contact length in each graft was taken 4 months after grafting. A ruler was placed along the union zone and the distance along which cambial contact existed between the stock and scion was measured to the closest millimeter.

Actual vertical cuts made on the stocks averaged 12.5 mm. for the short-cleft grafts and 63.5 mm. for the long-cleft grafts; a range of 51 mm. The amount of connecting cambial tissue between the graft types was further influenced by the number of union areas in which cambial contact between the stock and scion could occur. For example, a matched long-cleft graft could be considered to have four cut cambial edges each about 64 mm. long, whereas a mismatched long-cleft graft could have only two cut edges each about 63 mm. long (fig. 1). These two graft types differed by 130 mm. (64 X 4 minus 63 X 2) of cambial contact (table 1). The number of cut edges of contact varied from one to four, depending upon the graft type. Mismatched top-notch grafts and splice grafts had only one edge of cambial contact. Two edges were found on mismatched stub-cleft, saddle, short-cleft, and long-cleft grafts and on matched grafts of side, top-notch, and splice graft types. Four contact edges were present in matched saddle, short-cleft, and long-cleft grafts. Both splice graft treatments contain a component for horizontal matched cambium as well as for vertical cuts. Matched splice grafts had 10 mm. added and mismatched splice grafts had 5 mm. added to the vertical edge totals.

Length of scion tissue above the graft union was uniformly near 5 cm. Tissues on the scion through which water loss could occur should have been about equal between and within graft types. All needles and buds were left undisturbed on the upper scion areas.

Observations on scion elongation were made on August 11, 1966, when all 1966 elongation was completed. Survival was recorded on March 27, 1967.

Table 1.--First-year graft survival and scion elongation, by graft types and length of matched cambial edges

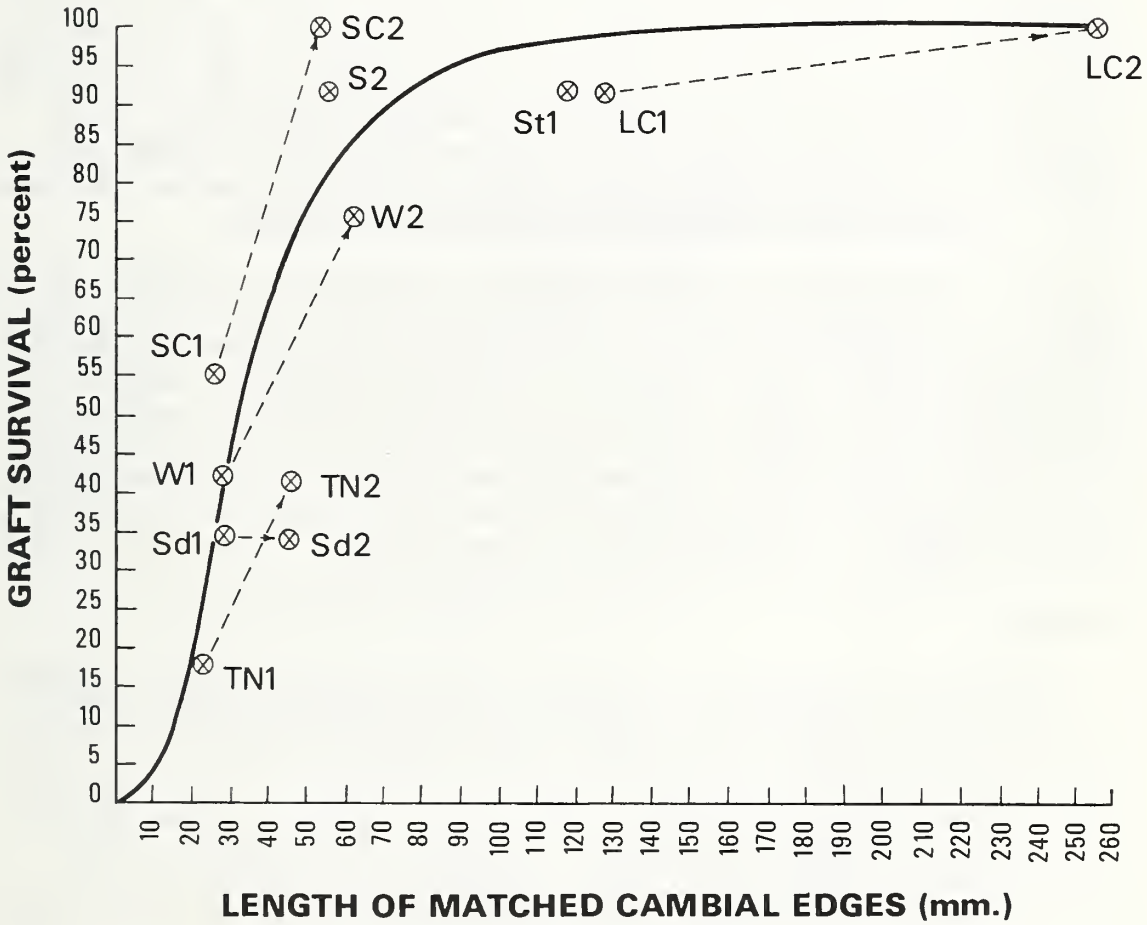
Graft type	Scion and stock match[1/]	Average length of vertical cut on stock	Average length of cambial contact between stock and scion	Average length of scion elongation (on August 11, 1966)	Survival on March 27, 1967
		Millimeters			Percent
Splice	Match	25	60	176	75
Splice	Mismatch	24	29	50	42
Long cleft	Match	64	256	257	100
Long cleft	Mismatch	63	126	189	92
Short cleft	Match	13	52	135	100
Short cleft	Mismatch	12	24	167	54
Saddle	Match	11	44	135	33
Saddle	Mismatch	14	28	66	33
Top notch	Match	22	44	51	42
Top notch	Mismatch	23	23	150	17
Side	Match	27	54	150	92
Stub cleft	Mismatch	58	116	274	92

[1/] Number of grafts is 12 except for stub cleft with 22.

RESULTS AND DISCUSSION

No assessment will be attempted concerning the type of graft that will result in highest survival the 1st year, as might be done if the original intent of the study were followed. When it was seen that within each graft type the matched grafts survived better than the mismatched grafts, the possibility of a relationship between survival and length of cambial contact was analyzed. Table 1, for example, shows that 1st-year graft survival between types ranged from 17 to 100 percent. However, most of this variation, as shown in table 1, proved to be related to length of matched cambium. Statistically, the relationship between survival and cambial contact was curvilinear and highly significant (r = 0.74**, 10 d.f.). Fifty-five percent of the variation was attributed to length of cambial contact (fig. 2).

Figure 2.--Field graft survival as related to length of matched cambial edges and graft types after 1 year.



The data indicate that field graft survival is very dependent upon water movement between the stock and scion. Grafts with long cambial contact areas have a greater surface through which water can pass. In the first 2 weeks following grafting, water must move from the stock to the scion through parenchyma cells rather than through mature tracheids (Braun 1962). During periods of high temperature and low relative humidity, grafts with little connecting tissue could become desiccated, and the grafts might die. If, as suspected, early graft failure is often due to scion desiccation, length of cambial contact would be of greatest importance when grafting is followed by warm, dry weather. Under this assumption, grafts made with long areas of cambial contact would survive better under those conditions than grafts made with extremely short unions.

As in the case of survival, grafts with more cambial contact generally had more 1st-year scion elongation than grafts with short unions (fig. 3). The relationship was linear and highly significant ($r = 0.71^{**}$). Fifty percent of the variation observed could be explained by cambial contact length.

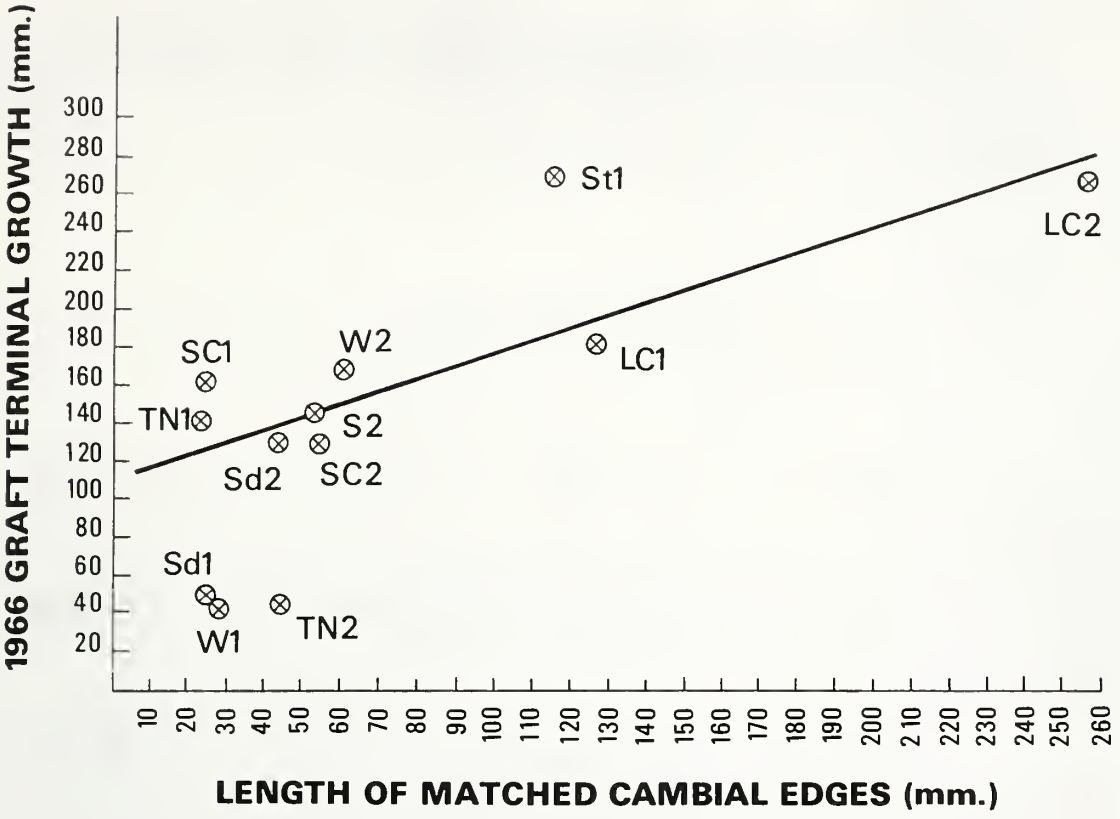
An interesting relationship between graft growth and graft position on the stock was indicated by the stub-cleft graft type. Its growth of an average of 274 mm. exceeded all other graft types. This was surprising when it is noted that the stub-cleft graft had an average of 116 mm. of cambial contact; however, the matched long-cleft had 256 mm. of cambial contact, yet its elongation averaged only 257 mm. This deviation from the expected is partially explained by the fact that stub-cleft grafts were made on the trees' main stems, whereas the other graft types were made on the tips of lateral branches.

This study presents rather persuasive evidence that cambial contact length is an important factor in early survival of Douglas-fir grafts. Because of study design, it is not possible to make valid comparisons between graft types due to the lack of similar lengths of cambial contact between graft types. There is some indication that survival of certain types is influenced by cambial contact length more than survival of other graft types (compare SC-1 and SC-2 and Sd-1 and Sd-2 in fig. 2). A study to test survival between graft types must hold constant the length of cambial contact. Such a test is underway.

SUMMARY

A study of seven types of Douglas-fir field grafts indicated that survival was dependent upon length of matched cambial union areas between stock and scion. For grafts with no more than 5 cm. of stem and foliage above the graft union at time of grafting, graft survival decreased almost linearly as the contact area became less than 75 mm. Little additional gain in survival was obtained by lengthening the matched cambial edges beyond 75 mm. First-year leader elongation was also influenced by cambial contact length, though not as strongly as survival.

Figure 3.--First-year scion elongation as influenced by length of matched cambial edges and graft types; August 11, 1966.



LITERATURE CITED

Braun, H. J.
1962. Water economy and water supply in tree grafts. Z. Bot. 50: 389-404.

Hartmann, Hudson T., and Kester, Dale E.
1959. Plant propagation principles and practices. 559 pp., illus. Englewood Cliffs, N. J.: Prentice-Hall, Inc.

Holst, M. J.
1956. Scion storage and graft protection in the spring grafting of red pine. Can. Dep. North. Aff. Natur. Resources, Forest Res. Div. Tech. Note 29, 11 pp., illus.

Kains, M. G., and McQuesten, L. M.
1942. Propagation of plants. 639 pp., illus. New York: Orange Judd Publishing Co.

Nienstaedt, Hans; Cech, Franklin C.; Mergen, Francois; and others.
1958. Vegetative propagation in forest genetics research and practice. J. Forest. 56: 826-839, illus.

Orr-Ewing, A. L., and Prideaux, D. C.
1959. Grafting methods for the Douglas fir. Forest. Chron. 35: 192-202, illus.

Mowat, Edwin L., and Silen, Roy R.
1957. A test of grafting ponderosa pine. U.S. Forest Serv. Pacific Northwest Forest & Range Exp. Sta. Res. Note 155, 5 pp., illus.

Shippy, W. B.
1930. Influence of environment on the callousing of apple cuttings and grafts. Amer. J. Bot. 17: 290-327.

Sitton, B. G.
1931. Vegetative propagation of black walnut. Mich. Agr. Exp. Sta. Bull. 119, 45 pp.

Webb, C. D.
1961. Field grafting loblolly pine. N. C. State Coll. Agr. & Eng. Sch. Forest. Tech. Rep. 10, 33 pp.

Zak, Bratislav.
1955. The grafting of shortleaf and other pine species. U.S. Forest Serv. Southeastern Forest Exp. Sta. Sta. Pap. 59, 13 pp., illus.